International Journal of Environment, Ecology, Family and Urban Studies (IJEEFUS)
ISSN(P): 2250-0065; ISSN(E): 2321-0109
Vol. 4, Issue 1, Feb 2014, 47-58

EFFECT OF SOC IN THE FORM OF AMENDMENTS ON RUNOFF AND EROSION OF ARID SOILS

GURUPRASAD M. HUGAR[1] & G. M. HIREMATH[2]

[1]Assistant Professor, Department of Civil Engineering, Government Engineering College, Raichur, Karnataka, India

[2]Department of Civil Engineering, Basaveshwar Engineering College, Bagalkot, Karnataka, India

ABSTRACT

Soil and water conservation is essential for sustaining food production and for preserving the environment. This study considers the potential of four types of soil amendments, namely humus, pressmud, bagasseash and flyash as a source of soil organic carbon (SOC) to amend with four arid soils namely black cotton, red, marshy and mountainous, obtained from organic farms. SOC inputs were made volumetrically up to 70% in the increments of 10% which resulted in 0.08 gm/gm-4.18 gm/gm for black cotton, 0.06 gm/gm-2.99 gm/gm for red, 0.06 gm/gm -3.16 gm/gm for marshy and 0.07 gm/gm -3.57 gm/gm for mountainous soil. There was also a control column without any external addition of SOC. The relation between SOC, erosion and runoff was analyzed by series of experiments carried in triplicate in three different phases based on the mode of application of SOC. The lowest runoff were 3.24%, 2.62%, 44.4% and 15.88% similarly lowest erosion were 1.77%, 0.95%, 1.7% and 0.44% for black cotton, red marshy and mountainous soils respectively. Phase I performed better for black cotton, phase II for red, phase III for marshy and mountainous soils with respect to runoff; while it was phase III for black cotton, phase II & III for marshy soil, similarly it was phase I & II that performed better for red and mountainous soils with respect to erosion.

KEYWORDS: Erosion, Runoffs and Soil Organic Carbon

INTRODUCTION

Land application of organic waste materials obtained from different sources has the advantage of preventing the accumulation of wastes in the environment and providing organic matter and nutrients for soils. The degradation of soil physical conditions and the risk of erosion are strongly related to a gradual decrease of the soil organic matter content in intensively cultivated soils (Giusquiani et al., 1995). Arid soils usually have low SOC content Angers and Carter (1996); Haynes and Swift(1990); Tester (1990). In such of the soils there is hardly any relation between SOC and soil stability (Levy and Mamedov, 2002; Goldberg et al., 1988; Coughlan and Loch, 1984). Previously Gigliotti et al. (1997) carried out a spectroscopy study to determine the changes in composition of dissolved organic matter in a soil repeatedly amended with municipal waste compost.

Erosion often causes changes in the biolog-soils and mask the effects of soil loss (Dormaar et al., 1988; Freeze et al., 1993; Cihacek and Swan 1994; Larney et al., 1995; Levy and Mamedov, 2002) leading to permanent reductions in crop measure and. Soil chemical properties can be offset with fertilizer by bringing the changes in soil physical properties (Ebeid et al., 1995; Frye and Blevins, 1982; Fahnestock et al., 1995; Lowery et al., 1995) especially water retention. The ability of soil to infiltrate and retain water is critical for plant production. Retention is affected by particle and pore size distribution. Therefore, in eroded soils, one can expect decreased water retention because of the preferential removal of clay and silt size particles that occur with erosion. However, if the lower soil horizons have greater clay content than the removed surface layers initially, soil water retention may increase, but not all this water will be plant-available

(Andraski and Lowery, 1992). Under such eroded conditions, soil water is held strongly, and additional energy is needed for plant uptake when compared with uneroded conditions. Eroded soils are usually shallower and plant roots have less volume to exploit for water and nutrients compared with less eroded soils. For these reasons, some researchers have observed a decrease in the available soil water capacity of eroded soils, whereas others have reported no differences, and even increases, in the water retention ability of eroded soils (Frye et al., 1982; Lowery et al., 1995; Fahnestock et al., 1995; Ebeid et al., 1995). Therefore, by SOC intrusion physical properties of eroded soil can be improved and it may be possible to ameliorate the harmful effects of erosion. This study was taken up with an objective of improving the physical properties of soil thereby controlling erosion and runoff of arid soils by utilizing organic wastes amendments.

MATERIALS AND METHODS

Study was conducted in Raichur a district head quarter located in the northern region of Karnataka state (16022’32.38”N 77021’38.50”E), which is drought prone and falls in the arid tract of the India. The climate of the district is characterized by dryness for the major part of the year and a very hot summer.

Soils used: A preliminary survey was carried out in different locations in and around Raichur, to select the soil samples for the study. Four soils namely black cotton, marshy, red and mountainous soil were taken from different locations by removing the top 5cm soil with ten samples from each location. Such of the collected samples were analyzed for particle size, field density and SOC as depicted in Walkely and Black (1934)

Soil Amendments

Flyash: Ash produced during combustion of coal, combustion has certain amount of loss on ignition (LOI) value that speaks of the unburnt matter this will still retain its organic carbon content (L. C. Ram et al., 1999; Indrek et al., 2004).Class “F” category procured from Raichur thermal Power plant of Karnataka, called Raichur Fly ash (RFA) was used in the study as a source of SOC and an amendment. Composition of Fly ash is given in Table 1

Bagasseash: Sugar cane Bagasse is an industrial solid waste obtained after having extracted the juice by crushing the sugar cane, it is used worldwide as fuel in the same sugar industry. The combustion yields ashes containing high amounts of unburnt matter, silicon and aluminum oxides as main components. Bagasse ash was obtained from the Core Green Sugar & fuels Pvt. Ltd. An Industry located in Yadgir, Karnataka, and composition of Bagasse ash is given in Table 1.

Humus: It is the plant/animal residue that does not completely mineralize. A certain part of this residue is more or less resistant to microbial decomposition and remains for a period of time as an un-decomposed or in a somewhat modified state, and may even accumulate under certain conditions. Typical composition of humus is given in the Table 1 (Selman, 1986)

Pressmud: Pressmud or filter cake, a waste by-product from sugar factories, is a soft, spongy, amorphous and dark brown to brownish material which contains sugar, fiber, coagulated colloids, including cane wax, albuminoids, inorganic salts and soil particles. By virtue of the composition and high content of organic carbon, the usefulness of pressmud as a valuable organic manure has been reported by several workers. Sugar press residue (SPR) or pressmud is a potential source of major minerals as well as trace elements that can substitute chemical fertilizers. Press mud was obtained from the above said sugar industry. Composition of Press mud is given in Table 1

Table 1: Composition of Amendments

Constituents	Flyash	Bagasse ash	Constituents	Humus	Constituents	Pressmud
	%	%		%		% (Except pH)
SiO_2	61.10	78.34	Water soluble fraction	7	pH	4.95
Al_2O_3	28.00	08.55	Hemicelluloses	18.52	Total Solids	27.87
TiO_2	1.30	1.07	Cellulose	11.44	Volatile Solids	84.00
Fe_2O_3	4.20	3.61	Lignin	47.64	C.O.D	117.60
MgO	0.80	-	Protein	10.06	B.O.D	22.20
CaO	1.7	2.15	Ether-soluble fraction	5.34	OM	84.12
K_2O	0.18	3.46	pH	5.6	N	1.75
Na_2O	0.18	0.12	SOM	0.83	P	0.65
LOI	2.40	7.42	SOC	0.28	K	0.28
SOM	0.89	0.85			Na	0.18
SOC	0.3	0.29			Ca	2.7
					SOM	0.71
					SOC	0.24

Particle Size Analysis of Soils and Amendments

Sieve analysis was performed for all the collected soil samples as per IS: 460-1962 and grouped accordingly in soil class. BC soil was clayey sand with high plasticity, having 38% sand and 62% silt & clay. Red soil was clayey sand with intermediate plasticity, having 41% sand and 59% silt & clay. Mountainous soil was silty sand with low plasticity, having 42% sand and 58% silt & clay and marshy soil was non Plastic, with 77% sand and 23% silt & clay.

Similarly Bagasseash particles were uniform non-granular and average particle sizes ranged between 7 µm to 12 µm, Fly ash had 1% clay, 12% of silt and 87% of sand content. Pressmud was coarser than rest of the amendments with its particle size ranging from 0.1µ to 1mm (20%), 1mm to 10mm (80%). Humus had 38% of fine sand fraction, 35% silt sized fraction and 27% clay sized fraction.

Test Procedure

Soil columns with dimensions 10 cm diameter and 30 cm length were fabricated by acrylic tubes and were then packed with the collected soil samples to their respective densities. The study was carried out in three phases based on the mode of application of SOC to soil as explained below.

Phase I: Soil-amendment combinations were individually assessed for their threshold SOC limits (based on obtained highest Water Holding Capacities) by replacing 0 to 40% volumes of soil with waste (SOC) and blending it with the top 50% depth soil, which resulted in 0.09 -0.55gm/gm with humus, 0.1-0.62 gm/gm with bagasseash, 0.2-1.19 gm/gm with pressmud and 0.08-0.5 gm/gm with flyash for BC soil. For red soil it was 0.07 -0.39gm/gm with humus, 0.07-0.45 gm/gm with bagasseash, 0.14-0.86 gm/gm with pressmud and 0.06-0.36 gm/gm with flyash. For marshy soil it was 0.07 -0.41gm/gm with humus, 0.08-0.47 gm/gm with bagasseash, 0.15-0.9 gm/gm with pressmud and 0.06-0.38 gm/gm with flyash. For mountainous soil it was 0.08 gm/gm -0.47gm/gm with humus, 0.09-0.53 gm/gm with bagasseash, 0.17-1.02 gm/gm with pressmud and 0.07-0.42 gm/gm with flyash.

Phase II: Soil-amendment combinations were individually assessed for their threshold SOC limits by replacing 0 to 70% volumes of soil with waste (SOC) and blending it with the complete soil depth, which resulted in 0.09 - 1.92gm/gm with humus, 0.1-2.18 gm/gm with bagasseash, 0.2- 4.18 gm/gm with pressmud and 0.08-1.74 gm/gm with flyash for BC soil. For red soil it was 0.07 -1.37gm/gm with humus, 0.07-1.56 gm/gm with bagasseash, 0.14-2.99 gm/gm

with pressmud and 0.06-1.25 gm/gm with flyash. For marshy soil it was 0.07 -1.45gm/gm with humus, 0.08-1.65 gm/gm with bagasseash, 0.15-3.16 gm/gm with pressmud and 0.06-1.32gm/gm with flyash. For mountainous soil it was 0.08 gm/gm -1.63gm/gm with humus, 0.09-1.86 gm/gm with bagasseash, 0.17-3.57 gm/gm with pressmud and 0.07-1.49 gm/gm with flyash.

Phase III: This phase was similar to phase II with the only difference that amendments were just stacked at top without blending with soil.

Determination of Runoff and Erosion

A channel of 20cm X 60 cm X 15cm was prepared with facility of a free board as shown in Figure 1 and the samples (control and amended soils) were placed in compartments such that the respective field densities are achieved and the setup was saturated and kept overnight. Water was then made to flow in the channel and the arrangements were made to collect the runoff water separately from both the compartments at the exit; also the infiltrated water was collected separately from the bottom of both the compartments from the base. Such of the collected volumes were quantified; similarly sediment collected was separated from water and was later quantified by drying.

Figure 1: Experimental Setup for Determination of Runoff and Erosion

RESULT AND DISCUSSIONS

To assess the impact of soil organic carbon (SOC) on erosion and runoff of arid soils, individual assessment of soil and waste amendment was made in particular with the mode of SOC application. The results so obtained are shown below phase wise with the suitable discussions.

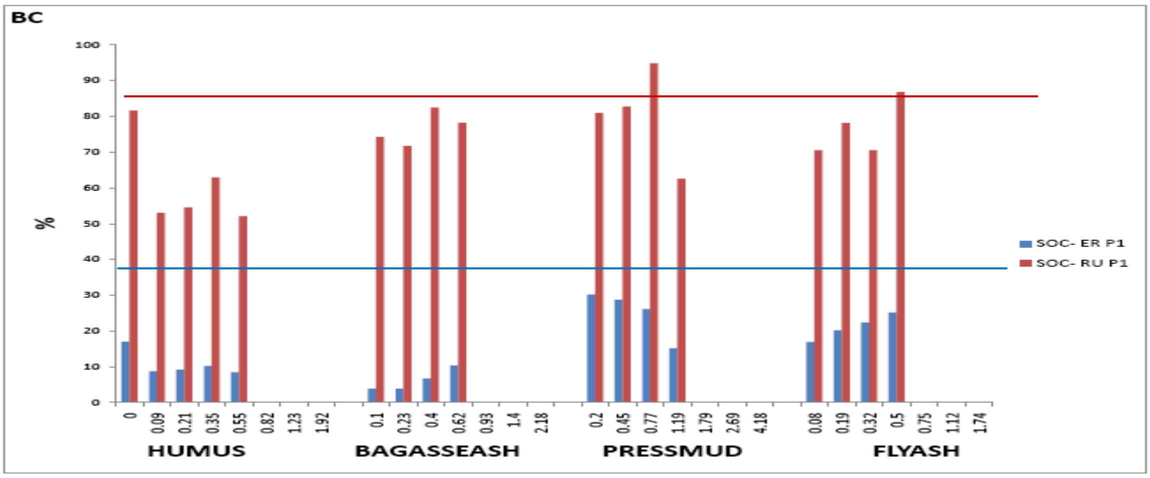

Figure 1a: SOC Vs Erosion and Run Off on BC Soil @Phase I

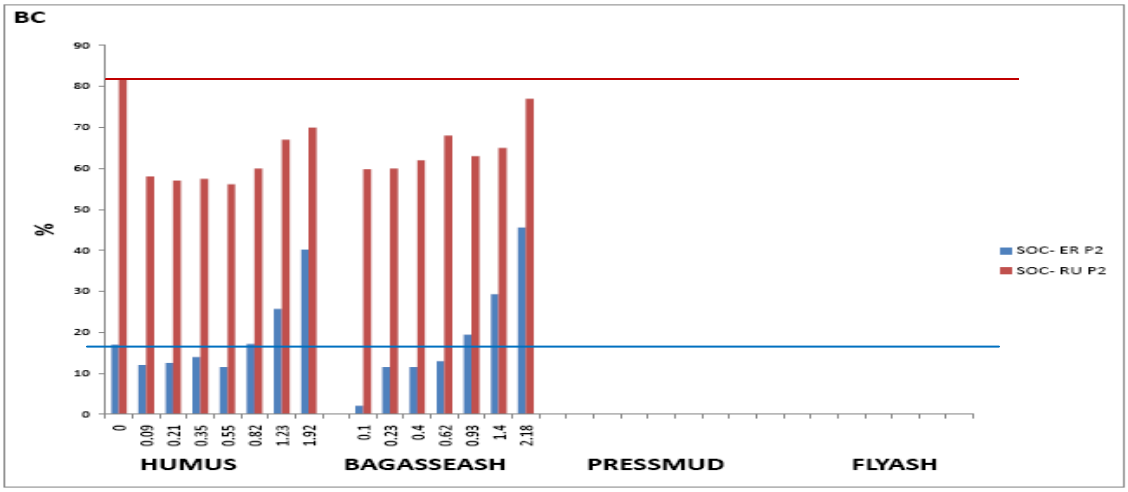

Figure 1b: SOC vs Erosion and Runoff on BC Soil @ Phase II

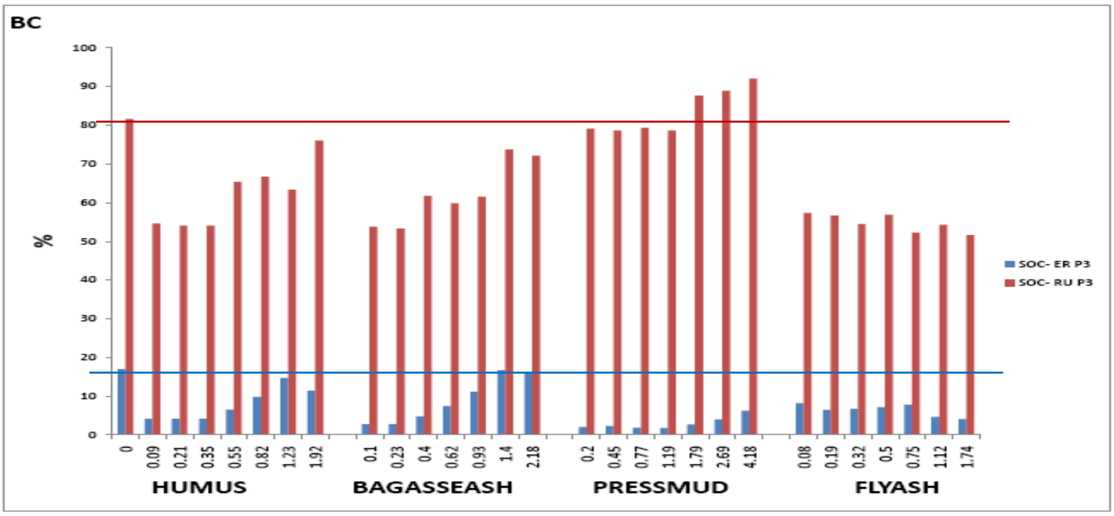

Figure 1c: SOC vs Erosion and Runoff on BC Soil @ Phase III

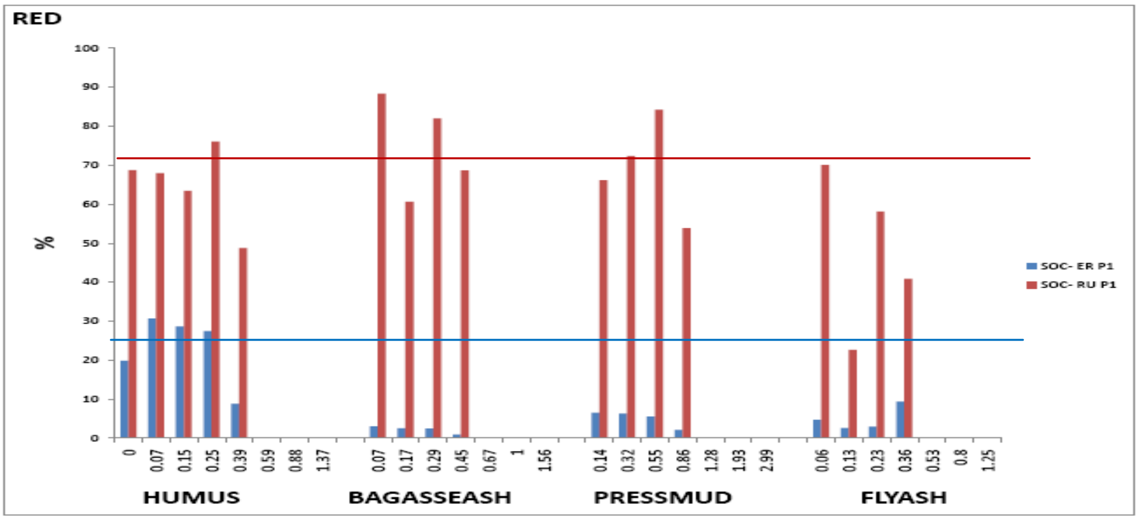

Figure 2a: SOC vs Erosion and Runoff on Red Soil @ Phase I

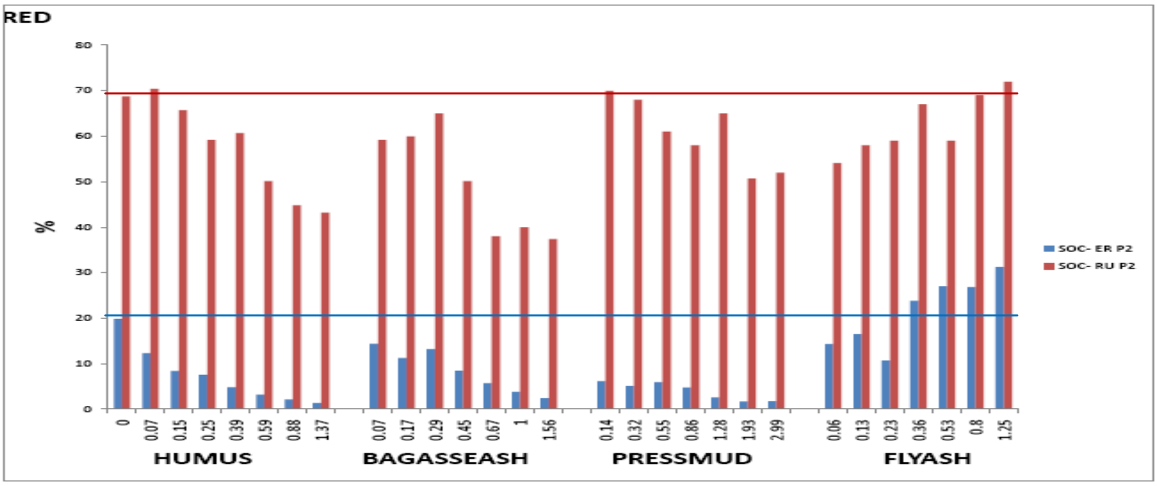

Figure 2b: SOC vs Erosion and Runoff on Red Soil @ Phase II

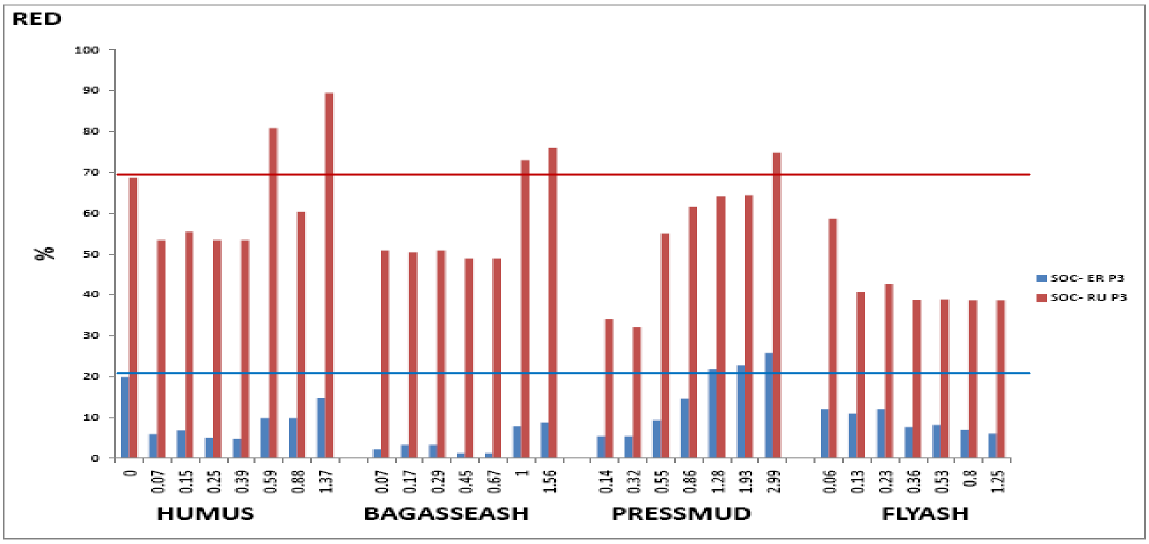

Figure 2c: SOC vs Erosion and Runoff on Red Soil @ Phase III

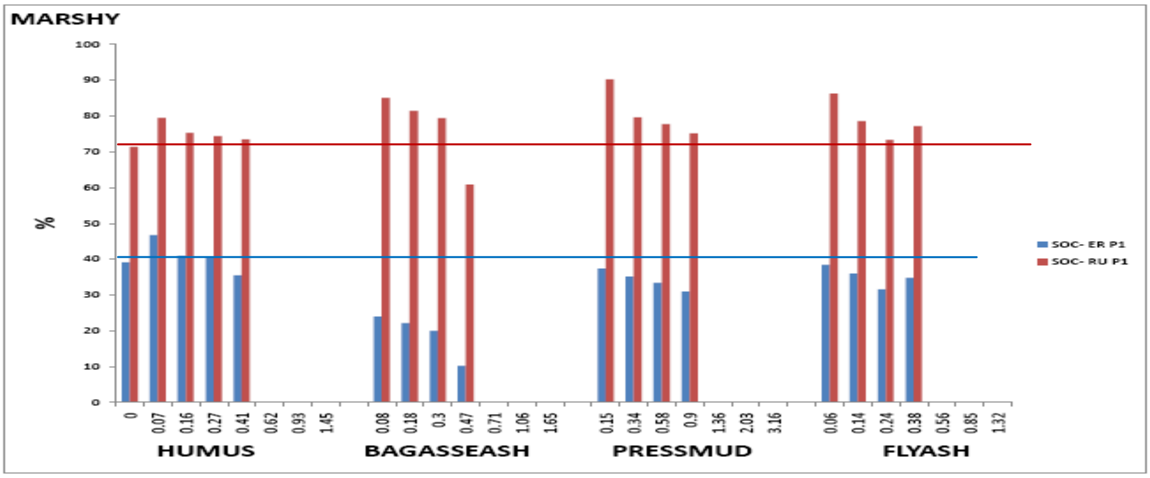

Figure 3a: SOC vs BD on Marshy Soil @ Phase I

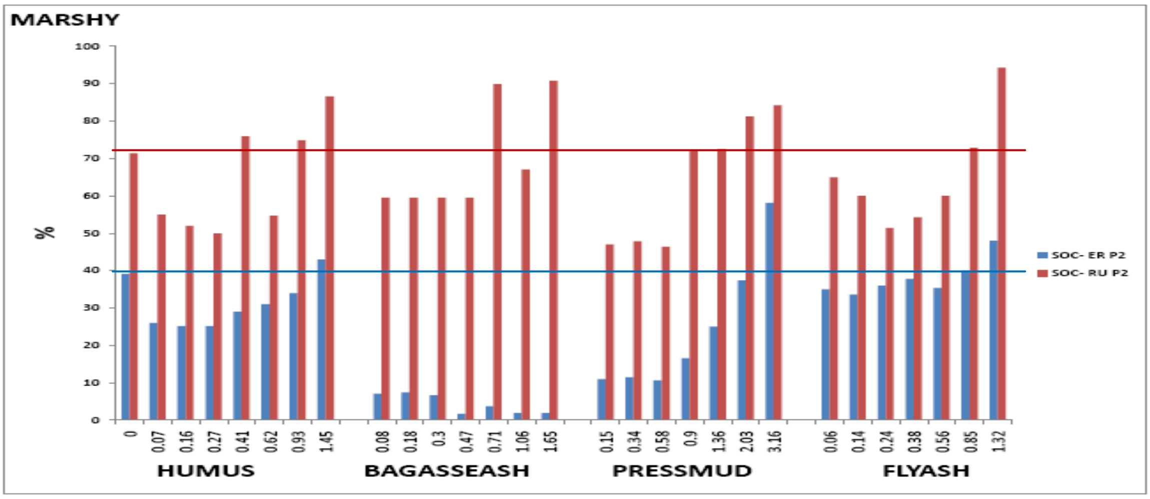

Figure 3b: SOC vs BD on Marshy Soil @ Phase II

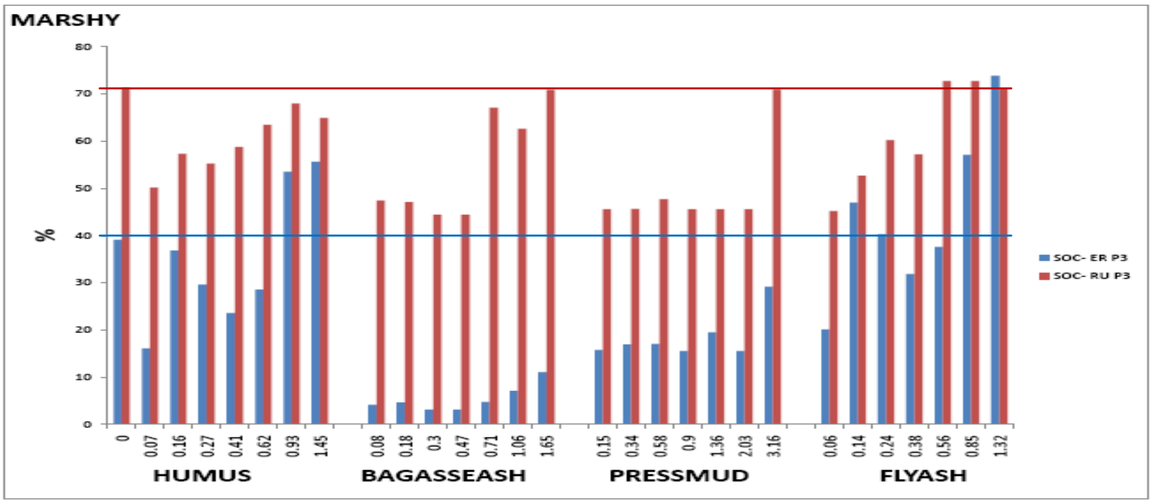

Figure 3c: SOC vs BD on Marshy Soil@ Phase III

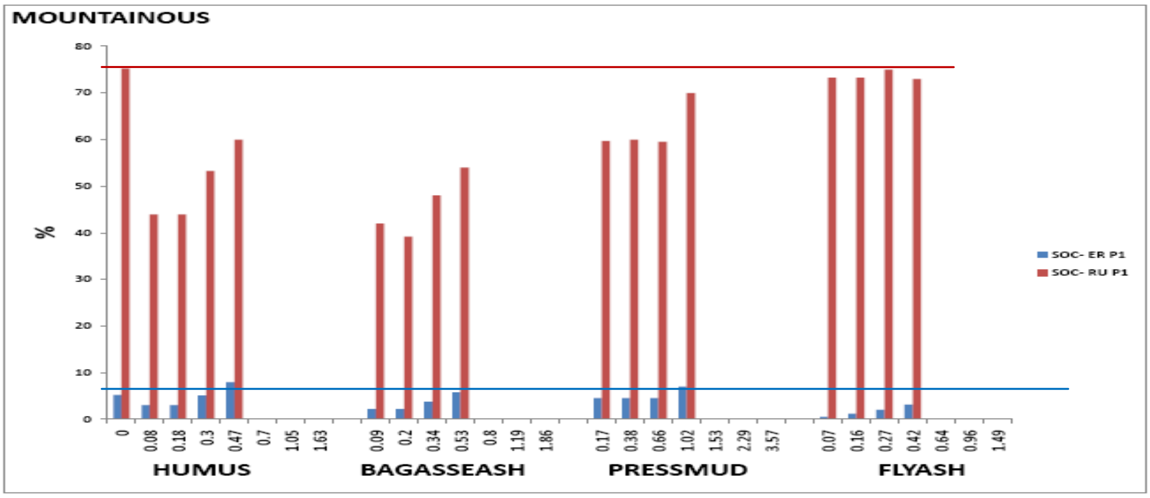

Figure 4a: SOC vs BD on Mountainous Soil @ Phase I

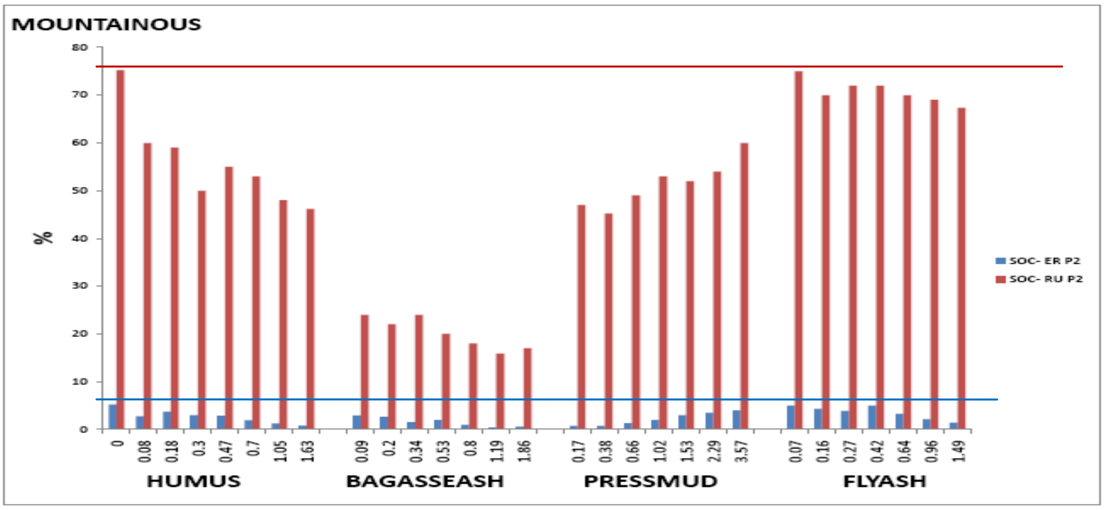

Figure 4b: SOC vs BD on Mountainous Soil @ Phase II

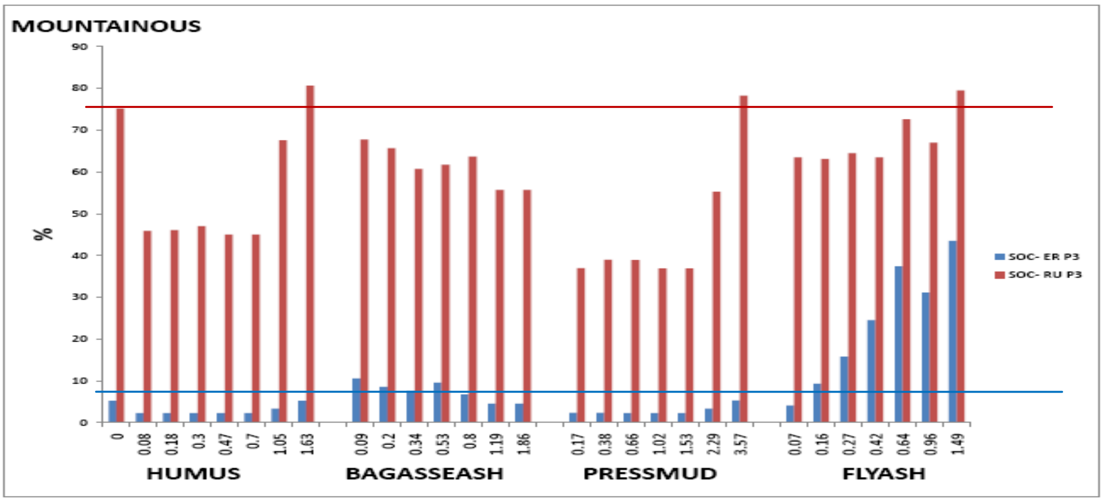

Figure 4c: SOC vs BD on Mountainous Soil@ Phase III

Erosion & Runoff

BC Soil*:* All the amendments reduced runoff and erosion in comparison with the control irrespective of phases). In phase I humus reduced erosion by 50% and runoff by 36% of control, bagasseash reduced erosion by 77% and runoff by 12%, pressmud reduced erosion by 10% and runoff by 23% of control. Flyash though reduced runoff by 14% it failed in controlling the erosion. In phase II humus reduced erosion by 32% and runoff by 31%, bagasseash reduced erosion by 87% and runoff by 26%. In phase III all the amendments reduced erosion by the range of 75-80% and runoff by 33-35% except bagasseash which hardly reduced runoff by 3%, as seen in Figure 1 (a, b & c). Bagasseash in phase I, humus in phase II and pressmud in phase III were efficient in reducing erosion; while it was humus in all the three phases that performed better in reducing runoff. BC soil performed better against erosion in phase III it is because leaching of the liquid matter from amendment enhanced the inflow of particle binding agents there by amplified the clod formation.

Red Soil*:* All the amendments reduced runoff and erosion in comparison with the control irrespective of phases. In phase I humus reduced erosion by 55%, while the rest reduced by 85- 95%. Flyash efficiently reduced runoff by as high as 67%. Humus and pressmud reduced runoff by 29% and 30%. While bagasseash performed least in abetting runoff. In phase II all the amendments reduced erosion by 90%, while flyash reduced by 45%. Runoff was better controlled by bagasseash by as much as 45%. Hums and pressmud reduced runoff by 37% and 26% respectively. Flyash under performed in comparison with the rest where runoff was reduced by only 14%. In phase III bagasseash super performed

than the rest in reducing erosion by 94%, humus and pressmud reduced by 75%, flyash was the least amongst in abetting erosion which was by 69%. Humus and bagasseash reduced runoff by 25%, pressmud reduced by 54% and flyash the least by 44% as seen in Figure 2 (a, b & c). Bagasseash in phase I & III and pressmud in phase II greatly reduced erosion in comparison with the rest. Flyash in phase I, bagasseash in phase II and pressmud in phase III greatly reduced runoff

Marshy Soil*:* All the amendments reduced runoff and erosion in comparison with the control irrespective of phases. In phase I bagasseash performed the best in comparison with the rest in abetting erosion which reduced by 75%, pressmud and flyash reduced by 20%, while humus reduced by less than 10%. Only bagasseash reduced runoff by 15%, while the rest increased the percentage runoff this might be because of resistance offered by the soil amendment blend. In phase II performance of amendments with respect to erosion was similar to phase I. Pressmud reduced runoff by 35% which was the highest, then followed by humus, bagasseash and flyash. In phase III bagasseash as in earlier cases reduced erosion efficiently by 92%, humus, pressmud and flyash respectively reduced erosion by 58%, 60% and 49%. Runoff reduction was more or less similar with all the amendments, as seen in Figure 3 (a, b & c). Bagasseash ash in all the three phases greatly abated erosion and runoff in comparison with the rest.

Mountainous Soil: All the amendments reduced runoff and erosion in comparison with the control irrespective of phases. In phase I flyash reduced erosion by 90%, which was the best reduction amongst the amendments. Humus and bagasseash reduced erosion by 45%, pressmud meagerly reduced by only 14%.Humus and bagasseash reduced runoff by 40% and pressmud by 21%, while flyash scarcely reduced runoff by only 2%. In phase II all the amendments reduced erosion by the range of 75% to 90%. Bagasseash reduced runoff by 79%, while humus and pressmud reduced the same by 40%. Flyash hardly reduced runoff by only 10%. In phase III humus and pressmud equally reduced erosion by 56%, bagasseash hardly reduced erosion by 12%, while flyash reduced by 22%. Pressmud super performed than the rest in abetting runoff by reducing to 51%. Humus, bagasseash and flyash respectively reduced runoff by 39%, 25% and 15%, as seen in Figure 4 (a, b & c).

Bagasseash in phase I & II greatly reduced erosion and runoff in comparison with rest. For phase III it was hums and pressmud that performed better in reducing erosion and runoff respectively. Incorporating SOC improved soil stability. When a raindrop hits bare soil, the energy of the velocity detaches individual soil particles from soil clods when the clods are week. The addition of organic residues enhances soil microbial biomass activity which transforms the newly added organic matter into materials which act to bind the fines and stabilize aggregates and holds soil particles together as aggregates. This helps soil to resist compaction, promotes water infiltration, and reduces runoff. Improves the soil's ability to store and transmit air and water, as measured by improved porosity; water holding capacity. Microorganisms also promote aggregation through the binding properties of their bodies, such as fungal filaments or bacterial gums and exudates.

CONCLUSIONS

A series of experiments were conducted to find the effect of organic carbon on erosion and runoff on arid soils using various wastes as source of SOC. A definite role of organic matter is found in promoting aggregate stability thus admitting much of rainwater inflow. The micro structure of all organic amendments was either filament or angular, while of flyash was spherical. Similarly microstructures of all the soils were angular except marshy soil that had nearly spherical shape. Hence the angular-angular combination of soil and amendment could break the momentum of flowing water thus reducing runoff and enhancing infiltration, thereby avoiding the self movement of soil and amendments along with water by acting as a covering blanket, protecting the soil from rain drop damage.

Not much appreciable gains with respect to erosion and runoff were seen in flyash amended soils. Mode of amending also had its role in controlling erosion and runoff. Blending with the top soil could strengthen only the top portion, hence blending the entire soil was the better choice this improved infiltration and all soils performed better in phase II. The coalition of organic fraction, the mode of blend and the microstructure of soil & amendment together have their influence in abetting erosion and runoff. Thus strengthening the crucial link between Waste utilization, land use, Storm water management and habitat restoration.

REFERENCES

1. Andraski, B. J., and B. Lowery. 1992. Erosion effects on soil water storage, plant water uptake, and corn growth. Soil Sci.Soc.Am.J.56:1911–1919.
2. Angers, D. A., and Carter, M. R. _1996_. "Aggregation and organic matter storage in cool, humid agricultural soils." *Structure and organic matter storage in agricultural soils*, M. R. Carter and B. A. Stewart, eds., Lewis, Boca Raton, Fla., 193–211.
3. Cihacek, L. J., and J. B. Swan. 1994. Effects of erosion on soil chemical properties in the north central region of the United States. J. Soil Water Conserv. 49:259–265.
4. Coughlan, K. J., and Loch, R. J. _1984_. "The relationship between aggregation and other soil properties in cracking clay soils." *Austral. J. Soil Res.*, 22_1_, 59–69.
5. Dormaar, J. F., C. W. Lindwall, and G.C.Kozub.1988. Effectiveness of manure and commercial fertilizer in restoring productivity of an artificially eroded dark brown chernozemic soil under dry land conditions. Can. J. Soil Sci. 68:669–679.
6. Ebeid, M. M., R. Lal, G. F. Hall, and E. Miller. 1995. Erosion effects on soil properties and soybean yield of a Miamian soil, western Ohio, in a season with below normal rainfall. Soil Technol. 8:97–108.
7. Fahnestock, P., R. Lal, and G. F. Hall. 1995. Land use and erosional effects on two Ohio Alfisols: I. Soil properties.J.Sustain.Agric.7:63–84.
8. Freeze, B.S., C. Webber, C. W. Lindwall, and J. F. Dormaar. 1993. Risk simulation of the economics of manure application to restore eroded wheat cropland. Can. J. Soil Sci. 73:267–274.
9. Frye, W. W., S. A. Ebelhar, L. W. Murdock, and R. L. Blevins.1982.Soil erosion effects on properties and productivity of two Kentucky soils. Soil Sci. Soc. Am.J.46:1051–1055.
10. Gigliotti G, Giusquiani P L, Businelli D & Macchioni A (1997) Composition changes of dissolved organic matter in a soil amended with municipal waste compost. Soil Sci 162: 919–926
11. Giusquiani PL, Pagliai M, Gigliotti G, Businelli D & Benetti A (1995) Urban waste compost: effects on physical, chemical and biochemical soil properties. J Environ Qual 24: 175–182
12. Goldberg, S., Suarez, D. L., and Glaubig, R. A. _1988_. "Factors affecting clay dispersion and aggregate stability of arid-zone soils." *Soil Sci.* 146_5_, 317–325.
13. Haynes, R. J., and Swift, R. S. _1990_. "Stability of soil aggregates in relation to organic constituents and soil water content." *J. Soil Sci.* 41_1_, 73–83.
14. Indrek Ku¨laots, Robert H. Hurt, Eric M. Suuberg, "Size distribution of unburned carbon in coal fly ash and its

implications", Science direct Fuel 83 (2004) pp.223–230.

15. L.C. Ram, S. K. Jha, G.K. Jha, M.C. Das, G. Singh, "Effect of fly ash from FSTPP on the cultivation of wheat and paddy crops in alluvial soil of Murshidabad district. In: L.C. Ram, (Ed.)," Proceedings of the National Seminar on Bulk Utilization of Fly Ash in Agriculture and for Value-added Products. Technical Session V. CFRI, Dhanbad, India, 1999a, pp. 200–210.
16. Larney, F. J., H. H. Janzen, and B. M. Olson. 1995. Efficacy of inorganic fertilizers in restoring wheat yields on artificially eroded soils. Can. J. Soil Sci. 75:369–377.
17. Levy, G. J., and Mamedov, A. I. _2002_. "High-energy-moisture characteristic aggregate stability as a predictor for seal formation." *Soil Sci. Soc. Am. J.*, 66_5_, 1603–1609.
18. Lowery, B., J. Swan,T .Schumacher, and A.Jones.1995.Physical properties of selected soils by erosion class J. Soil Water Conserv. 50:306–311.
19. Selman A. Waksman, "Humus Origin, Chemical Composition and Importance In Nature-1986", Baltimore The Williams & Wilkins Company
20. Tester, C. F. 1990. Organic amendment effects on physical and chemical properties of a sandy soil. Soil Sci.Soc.Am.J.54:827–831
21. Walkley, A. and I. A. Black. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. 37:29-37.